Cross-analysis of the accessibility instruments

Cross-analysis of the accessibility instruments presented in section 3

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In the following, we look at how the different accessibility instruments presented in section 3 compare on the different aspects: background, conceptual framework and theoretical underpinnings, operational aspects, relevance for planning practice, strengths and limitations, and visualization. We identify, per item, significant similarities and differences and reflect on potential implications for the following steps of the Action.

Section 1 – Background

The main motivation to develop an accessibility instrument can be roughly divided in three categories: policy and planning support, scientific enquiry, or a combination of the two. The borders between these categories are not always clear cut. However, based on the motivation expressed by the authors and for the sake of orientation, 10 of the 22 instruments reviewed in section 3 can be placed in the first category, 4 in the second, and 8 in the third.

Within the instruments primarily motivated by a policy support aim, two groups can be identified. A first group is primarily directed at supporting policy *development and delivery* in a multi-disciplinary (both transport and land use) and multi-stakeholder (including different levels of expertise) context. Examples are Snamuts/chapter 1, EMM/chapter 7, InViTo/chapter 10, and Joint accessibility design/chapter 12. A second group rather aims to develop tools for the *assessment* of land use and/or transport development proposals and/or service provision. Examples are Retail Cluster Accessibility/chapter 2, RIM/chapter 8, Method for arriving at maximum recommendable size of shopping centres /chapter 13, Isochrone Metrosur/chapter 18, SNAPTA/chapter 21, and ACCALC/chapter 22.

On the other extreme of the spectrum are instruments that are primarily motivated by scientific enquiry, even though the potential relevance for planning is also envisaged, as it might be expected from participants in this COST action. In this category fall Himmeli/chapter 5, GDATI/chapter 14, Cellular automata modeling for accessibility appraisal/chapter 16, and Social spatial analysis/chapter 20.

A middle category is rather above all motivated by the wish to innovatively apply in planning practice insights already fairly consolidated in the scientific domain. The Space Synthax inspired instruments described in chapter 3, 9, and 19 fall in this category. Other examples are Activity based indicators of connections and access needs/chapter 4, Contactability/chapter 6, Gravity based indicators for integrated transport and land use planning/chapter 11, SAL/chapter 15, and From accessibility to the land development potential /chapter 17.

This variety of motivations is both a challenge and an asset for the COST Action. It is a challenge because it demands establishing a common language and sense of direction between researchers coming from different backgrounds and having different primary motivations. It is an asset because it gives the Action a rich variety of expertise spanning the scientific and policy domains. Such variety seems essential for our aim of establishing a bridge between scientific enquiry and policy practice.

Section 2 - Conceptual framework and theoretical underpinnings

The ease or difficulty in reaching different activities dominates among the instruments as a conceptual definition of accessibility. What kind of activities or services are included in measurements varies more or is not reported in a very detailed way. Some of the instruments focus on certain services like retail and shopping (e.g. Retail Cluster Accessibility, Method for arriving at maximum recommendable size of shopping centres), some approach public transportation or technical infrastructure as service (to be accessed) (e.g. InViTo, From accessibility to the land development potential) while others approach transportation and infrastructure as a system which enables the access to activities or services. Several different activities are taken into account for example in instruments like ‘SAL’ and ‘Gravity-based accessiblity measures for integrated transport-land use planning’.

One clear group of instruments concentrate only on the physical and configurational aspects of the space and define accessibility in terms of the topological network properties of urban space using transportation network or other networks based on visual perception. ‘Spatial Integration Accessibility’ and ‘Measures of Street Connectivity –Spatialist _Lines’ are examples of instruments that are based strongly on space syntax approach. Some of the instruments settle between these two like ‘Place Syntax tool’ or have a more individual approach to the accessibility concept.

The theoretical underpinnings vary from geography to architecture. Most of the activity related instruments utilise gravity based accessibility measures and are thus related to the modelling tradition of urban geography. Instruments that emphasise the spatial and structural properties of urban environments mostly refer to the ‘space syntax school’ which has its origins in architecture and urban morphology. Instruments that are part of larger model structures, like ‘Himmeli’ and ‘Cellular automata modeling for accessibility appraisal’ are related to different traditions of modelling theories like systems theory, complexity theory and the theory of cellular automata. Some instruments like ‘Activity based indicators of connections and access needs’ refer to time geography or information visualisation. A significant part of the instruments are not reported having any theoretical underpinnings, but they are merely developed for normative planning purposes.

The motivation for choosing and developing the instruments is generally an aim to support strategic planning decisions – especially the focus is on the integration of transport and land use planning. Some of the reports emphasise more economic issues and assessment of investments while others emphasise more social aspects e.g. social equity. Differences can be seen also between normative tools that are developed to set certain (unambiguous) standard solutions for planning (e.g. maximum travel times to services or minimum customer potential within given distance) and more analytical tools that don’t include straightforward instructions for planning but rather increase understanding of the interdependencies between urban elements.

Section 3 - Operational aspects

The authors were asked to give an answer to the following questions:

- Which types of accessibility does the instrument measure?
- How does your instrument calculate accessibility?
- Which data is required? Is the data publicly and freely available? If not at which conditions can it be obtained?
- How is the data processed? What are the hardware and software requirements? Is the software publicly and freely available? If not, at which conditions can it be used?
- How much time does the calculation require?
- Which degree of technical expertise is required to perform the calculation?
- Which degree of technical expertise is required to interpret the results?

The responses to these questions are summarized below.

Instrument	*Type of Accessibility*	*Data required & availability*	*Calculation requirements*	*Expertise*
SNAMUTS	- Relation between public transport (PT) service and land use (LU) activities - Utilizes six indicators: 1) easiness of movement along PT network; 2) directness of journeys on PT 3) combine effect of PT on LU intensity 4) competitiveness of PT vs car 5) geographical distribution of attractive travel paths 6) nodal connectivity	Not described	**Time** Not described **Software** ArcGIS	Not described
Retail Cluster Accessibility	- Distance of retail clusters to relevant infrastructure (e.g., train stations, major roads) - Other accessibility measures could be calculated (such as gravity-based)	- Geo-referenced data of shops - Type o retails, net floor surface, and type of shopping area - Data available from Locatus database (payable)	**Time** 1 to 1.5h for a set of 34000 records in a mid-range laptop **Software** ArcGIS with Spatial Analysis extension	- Both performing calculations and understanding the results is relatively easy - The tool is intuitive and can be used by anyone familiar with ArcGIS

Spatial Integration Accessibility	- Degree of spatial separation/integration - Travel from one line to another across the graph in topological terms (referred to as *depth*)	- Axial (vector) maps, with the set of lines of sight passing through every public space - Automatically generated from vector maps or manually from image files of maps	**Time** Few minutes for small urban areas Few hours for a city **Software** Depthmaps (Windows) is publicly and freely available Open-source	- The analysis is calculated automatically without any special knowledge or technical expertise - Broad knowledge on theory of space syntax is needed to interpret the results
Activity Based Indicators of Connections and Access Needs	- Activity based indicator - Visualization of interaction patters – desire-line traces that indicate loads, demand for capacity, and spatial patterns of dependency and centrality.	- OD datasets (generally not free) - Danish case: obtained from either Danish commuter survey or the Danish National Travel Survey	**Time** Not described **Software** Software to handle with large datasets, geo-statistics and maps (e.g., ArcGIS or open-source R)	- Handling of data and analysis does require some technical expertise (more than general GIS courses)
Himmeli	- Proximity of households (Hhlds) to retail units in travel cost - Clustering of each retail units (with respect to other retail units)	- Data concerning Hhlds + retail services (typology and location) and transportation systems (travel cost matrix)	**Time** 20000 discrete spaces = 50 minutes **Software** MapInfo (script coded in Basic and C#)	Not described
Contactability	- Travel time using public transport (rail and air)	- Data available from OAG (www.oag.com) for flights and by automatic queries of the public website DieBahn.de for the train timetables	**Time** 1,5 months to do a case study (from data collection to cartography) **Software** MySQL+Musliw (not publicly available)	- The degree of technical expertise is high for calculation and processing information - The degree of technical expertise for interpretation is low

Erreichbarkeitsatlas der Europäischen Metropolregion München	- Regional Level: gravity index that estimates accessibility to population and job potentials (travel time in car and transit) - Local Level: large variety of indicators combining travel times in car, transit, cycling & walking, analyzing accessibility to facilities, transport hubs, and other POI	- Structural data: population and employment (public in Germany at the municipality level) - Transport data from OpenStreetMap (free-online), transit web-sites	**Time** Varies but is generally high (several hours to several days) **Software** Online (GIS-based) tool has been developed that, currently, is still not publicly available	- Only usable by experienced modelers (GIS & databases) - No technical skill will be needed to access the online tool
German Guidelines for Integrated Network Design	- Journey times between central locations and residential areas - Transport network sections are classified according to the level of central locations connected and their function	Not described	**Time** Not described **Software** Not described	Not described
Measures of Street Connectivity – Spatialist Lines	- Street connectivity (space syntax)	- Street centre line information from standard GIS street network or CAD files	**Time** Ranges from seconds to few hours **Software** Spatialist_lines (upon request) - plugin of ArcView	- Basic knowledge of GIS software to perform calculations - Visual maps are easy to understand
InViTo	- Walking time from the nearest public transport access point	- Network information (usually free from OpenStreetMaps)	**Time** Not described **Software** Rhinoceros (commercial) combined with its free plug-in Grasshopper	Not described

Gravity Based Indicators for Integrated Transport and Land Use Planning	- Gravity indicator for: * residents towards workplaces * economic activities towards residents - Distance measured in generalized travel cost	- Socioeconomic (National Statistics) - Land use characteristics and transport network	**Time** Not described **Software** TransCAD GIS software	- The use of the software requires a medium level of expertise, for calculation and interpretation
Joint Accessibility Design	- The accessibility measure varies with the applications - Are related to societal goals (cohesion, competitiveness, sustainability) - The accessibility is measured with a distance decay function	- Spatial and travel time data (usually owned by municipalities)	**Time** One day for travel times calculation + 15 min for maps production **Software** ArcGIS	- GIS skills are sufficient
Method for Maximum Recommendable Size for Shopping Centres	- Real walking distance from dwelling to shopping center	- Residences location - Retail structure (time spent on shopping, turnover, etc) - Plans and probable developments - Population extrapolation - Spatial GIS data - Data available in a plan-making process	**Time** Not very work-consuming **Software** ArcGIS	- No advanced skills are needed - Planning knowledge is the main competence necessary

Geographic and demographic density of public transport networks and stops	- Geographic and demographic accessibility of transit linear and punctual infrastructure	- Geographic and demographic data (obtained from GIS maps) - Transport data can be obtained online or via transit operators	**Time** Calculations are not time-consuming, data collection is! **Software** Not described	- Basic level of technical knowledge is needed to perform calculations - Advanced level of technical knowledge is needed to interpret results
Structural Accessibility Layer	- Compares the variety of travel generating activity types reachable by different transport modes within a given travel time/cost limit	- Geo-referenced data (population, employment, activities location - by CENSUS; transport infrastructure, service level, demand) - The data is generally purchased and owned by local authorities	**Time** May reach out to weeks **Software** GIS with network analysis	- Advanced technical skills are needed if no processing scripts are available - Results are easy to understand, considering both perceptions of accessibility and map reading
Cellular automata modeling for accessibility appraisal in spatial plans	- Travel time by private car - Land use changes are used to represent accessibility variations throughout time (forecast)	- Land use information (obtained from National Statistics and local planning authorities) - Transportation network, including future investment/change planned (obtained from local authorities)	**Time** Vary from hours to 1.5 days **Software** Standalone Visual Basic tool	- Some GIS expertise is needed to preprocessing data - No specific expertise is needed to interpret results

Accessibility to the Land Development Potential	- Physical distance and capacity of the existing and proposed technical infrastructure - Accessibility is determined by 1) the distance; 2) the capacity of elements; 3) costs.	- Land use info, density, housing construction typology, land subdivision, private/public land ownership - Technical infrastructure data (distance, capacity, etc) - Most data is available for free in public records; others can be measured; others will be based on surveys and workshops	**Time** Not described **Software** ArcGIS with spatial analyst	- The interpretation of the results will be easy
Isochrone maps to facilities	- Travel time by transit to shopping centers	- Digital transit network (with travel times, scheduling, transfer times, stations/stops etc) - Street network (for walking times) - Location of shops - Population data	**Time** Not described **Software** ArcGIS & EMME3 for traffic assignment (commercial) or other traffic assignment software	- Some technical knowledge of network analysis using GIS is required - Results can be understood by everyone
Place Syntax Tool	- Space syntax	Not described	**Time** Not described **Software** Place Syntax Tool for MapInfo - a DLL library coded in C/C++	Not described

Social Spatial Influences of new Transport Infrastructure	It measures different types of accessibility and compared over the years: - travel times between municipalities - connectivity - rent market changes (social)	- All the data is available but needs own investigation and research - All observations are long-term observations within 5 up to 10 years	**Time** Depends, but no longer than one or two weeks. However, it has to be repeated every year, maybe more often. **Software** No soft- or hardware is needed but a statistical program, such as SPSS, can be used	- No special requirements in technical expertise are needed - Some interest in social sciences and empirical methods will help
SNAPTA	- Time access to city center by transit - Total number of economic activities or destinations within a defined catchment area using transit - Gravity-based measure using morning PH travel times and quantity of activity opportunities per zone	- Population: uses UK Census Data Zones - Jobs, gross floor area of retail shops and facilities, number of patients: obtained under license from government organization - Number of students per school and university, number of recreation facilities: obtained from websites - Transportation network info	**Time** - Data collection is very time consuming - Running SNAPTA in GIS does not take a long time **Software** GIS (ARC/INFO)	- Data input and performing the calculation requires a good knowledge of GIS - The easiness of interpretation of results depended on the accessibility measure used

ACCALC	- Travel time or costs for different purposes and for different periods of the day, by different modes (transit, walking, etc),	- Land-uses, data on locations, OD demand data, travel times, etc - Data has become much more freely available over the last 2years with the open data government initiative. - Data on commercial facilities, like shops and theaters, can still be quite expensive to purchase	**Time** - Building the matrices takes many hours; - Once built, ACCALC uses these matrices and can analyze policy questions in real time **Software** - Microsoft Access or MS SQL (recently) + Excel - ACCALC is hoped to provide web-based user front end so that anyone can use the tool free of charge	- A high level of technical expertise is needed to run the analysis

Significant similarities and differences are:

- Most instruments deal with aggregated measures of accessibility, by either considering a network distance (despite the mode) or the different modes together;
- The techniques for computing accessibility, when mentioned, vary from spatial syntax (3) and gravity models (5), to activity based (2), social based approaches (2) and clustering (1);
- Part of the instruments (6 of 22) deal with the impact of land-use changes, some instruments deal with accessibility to stores, while few deal with the accessibility to facilities;
- In general, data needed is transportation info (maps, OD matrices, times/costs) and population data. Most of the authors mention that the info they need is available on the web (10 of 22) or is provided by planning/local authorities (7 of 22). Only 5 authors mention that data must be purchased;
- No clear idea of computation time is always provided – the time for applying the instruments depend on the type of tool used and the size of the case study, but most of the authors mention the duration of hours or days;

- 14 of the instruments are based on GIS software, 2 use data management software, and only 6 authors mention that they use (or developed) open source tools;

- The level of expertise need to use the instruments also vary between instruments – 6 authors mention that no specific expertise is needed to use the instrument and 10 mention the same for interpretation of the results; 3 authors mention that a high level of expertise is needed for preparing data, 7 to use the instrument, and 4 to read the results.

Potential implications for the following steps of the Action are:

- The summary shows that different accessibility techniques are being used and different transport modes are focused upon by the authors. The compatibility of these different perspectives can be a major challenge for the Action but it also proves the wide coverage of this Action;

- In the same way, some authors focus on urban-level accessibility, while others focus on neighboorhood-level accessibility (e.g., walking or cycling distance) and others on interregional-level accessibility (e.g., long distance trips by rail or air). The merge of both scales, by using more than one instrument in the future can be a potential goal for accessibility research - by my understanding, the Erreichbarkeitsatlas and Joint accessibility design instrument are the only instrument presented in the reports that already merge a regional and a local scale.

- Most authors present instruments that deal with accessibility in a static fashion, i.e. they try to get the picture for a given scenario (in the past, present or future), but 3 authors mention that their instruments focus on measuring the impacts on time of land use changes and impacts of infrastructure investments. The Action may explore these different approaches, trying to understand how they can differently be used by planners and, if they provide different answers, for which uses which approaches can be better.

Section 4 - Relevance for planning practice

Each of the reports attempted to address the following questions:

- What information does your instrument produce that can be useful for planning practitioners?

- Has the instrument been used before in a real planning context?

<u>If yes:</u>

  - Where and when?
  - Which planning problem, or problems, did the instrument address?
  - How did the instrument help in decision-making?
  - What difference did it make in the planning outcome and/or in the decision-making process?

<u>If no:</u>

- Why not?
- Has the possibility of using the instrument to address a planning problem and support a decision-making process been otherwise explored? If yes, provide a brief description of the planning problem and how the instrument can provide support to decision makers.

The responses to these questions are summarised below.

Instrument	*Information Produced*	*Use in real planning*
SNAMUTS	Visualises a public transport network's strengths and weaknesses Interactive design tool for scenario planning	2007 - Perth radial suburban railway and land use plans for intensification of activities 2009 – Benchmarking accessibility between cities 2009 - Impacts of orbital bus service in Melbourne
Retail Cluster Accessibility	Developed and tested to analyse retail landscape in Flanders. Analysing balance between sector efficiency and spatial goals	Not identified
Spatial Integration Accessibility	Space Syntax spatial configuration of social issues	Not identified
Space Syntax and the Structural Accessibility Layer	Describes links between space quality, environmental characteristics and pedestrian activity	Not identified
Activity Based Indicators of Connections and Access Needs	Analysing the connectedness of a municipality towards other areas	Research project referenced in practice
Himmeli	Observation of factors behind different development paths allowing planners to influence development more effectively	Not as yet
Contactability	Travel times using public transport to compare cities	Used in a competitiveness indicator for cities
Erreichbarkeitsatlas der Europäischen Metropolregion München	Potential for transit orientated development Neighbourhood accessibility Indicators for land use planning	Mainly in development stage but has been used in stress tests for sustainable mobility showing resilience of places to energy price fluctuations.

German Guidelines for Integrated Network Design	System of central locations for defining spatial components of standards Set standards for slow modes and public transport for improvement and for car to maintain current standards	Standards set and guidance issued to authorities.
Measures of Street Connectivity – Spatialist Lines	Measures of connectivity including spatial and cognitive influences on behaviour	2010 - master-plan for the King Abdullah University of Science and Technology Science Town
InViTo	Relationship between facilities and settlements as an influence on localism	Pilot in northern Turin to investigate the transformations resulting from the new subway Identifying new functions in the city of Asti
Gravity Based Indicators for Integrated Transport and Land Use Planning	Spatial distribution of accessibility levels	Many applications most recently the Regional Metro System Plan of the Campania Region (South-Italy)
Joint Accessibility Design	Develop measures jointly with practitioners in each local setting	Collaborative approach largely research so far but undertaken in the context of current real planning problems in the Netherlands
Method for Maximum Recommendable Size for Shopping Centres	Number of square metres of shopping space recommended to serve a population	Applied by planning authorities in Oslo for some years.
Geographic and demographic density of public transport networks and stops	Various indicators relating public transport network characteristics to urban density	Only used in research so far
Structural Accessibility Layer	Diversity of accessibility indicator Accessibility cluster indicator	Information on spatial inequalities used in research in Oporto
Cellular automata modeling for accessibility appraisal in spatial plans	Simulate different planning scenarios of land use evolution taking the influence of the transport system explicitly into account.	Not yet fully used in real-world planning processes but to be tested shortly

Accessibility to the Land Development Potential	Indicators of different degrees of accessibility presented separately for example different services or combined	Under development and not yet applied
Isochrone maps to facilities	Total population within time thresholds to measure accumulated opportunities	Applied in 2005 in the Autonomous Region of Madrid, in a collaboration between the regional Public Transport Authority and the Regional Health Department
Place Syntax Tool	Axial distance to facilities	Application in research on access to green spaces.
Social Spatial Influences of new Transport Infrastructure	Accessibility to infrastructure defined in terms of economic, ecological and social evidence	Development not completed
SNAPTA	Zonal accessibility by public transport to show impacts from transport infrastructure changes	Development recently completed and not yet applied
ACCALC	Car and non car user accessibility opportunities to various land uses in terms of travel time and accessibility opportunities	Used by Scottish Government and local authorities since 1999 and recommended as a suitable tool in Scottish land use planning guidance and Scottish transport appraisal guidance. Used by UK department of transport for calculating neighbourhood statistics across UK.

Significant similarities and differences among the reviewed instruments with respect to planning practice are:

- Some are tools to aid calculation
- Some are expert systems to help define and answer problems
- Some are repeatable analytical methods using existing and widely available tools like GIS systems

Potential implications for the following steps of the Action are:

- Where there are clear policies defined for accessibility, then tools have an application since they can be optimized to implement the policy and make calculation easier.

- Where accessibility analysis contributes to another policy goal like transport or land use planning then repeatable analytical methods can be most useful.
- Accessibility can be a difficult concept so both of the above can use expert systems to guide people through the process of data collection, analysis, policy formulation and planning.

Section 5 – Strengths and limitations

The variety of motivations for developing the accessibility instruments and the even greater variety in their content focus mean that it is difficult if not impossible to synthesize their strengths and limitations. The discussion here would therefore have to be at a high level of abstraction and be limited to the most salient issues.. For more concreteness and detail we refer to the individual chapters.

A key strength cited by most if not all is the ability of the instrument to link (1) some information on transportation networks, land uses and the urban fabric, to (2) their impact on location and mobility behavior and therefore (3) implications for the achievement of policy goals ranging from economic development, to social equity and environmental preservation. In the view of the instrument developers accessibility, in its various forms, is a (if not *the*) key indicator of the performance of the built environment. Most authors would subscribe the view of the Auditor General in Scotland reported in chapter 22 that 'if there was only one type of indicator local authorities could monitor it should be accessibility, since accessibility is the most useful way to demonstrate the opportunities available to citizens for health, education, work, leisure, etc.'

A second key strength cited by many is the straightforwardness, ease of interpretation and communicative power of the indicators, often in map form. These last claims, however, are not always supported by actual applications in planning practice, or by applications going beyond a pilot study , as documented in the previous section. Accordingly, several authors also cite the need to embark in practice applications and to learn through them how usable the instruments actually are, and how to improve usability.. This provides, of course, a clear focus for the next steps of this Action.

Requirements in terms of data availability, calculation time and technical expertise are also often cited as limitations and areas of improvement. Other areas of improvement mentioned concern, perhaps somewhat contradictorily with the previous ones, the need to extend the range of inputs (e.g. more transportation modes, more qualitative urban morphology features) and outputs (e.g. more impacts), or to increase the realism of the underlying behavioral assumptions (e.g. by including distance decay and competitions effects, or transport-land use feedback mechanisms). Some of the authors, however, point to the fact that models are by definition limited in their realism, and that the aim should rather be to ensure that the accessibility instrument is transparent in its assumptions and logic, and easy to use. They further contend that complexity should rather be added by also using other instruments, or through the discussion with other experts and stakeholders. The rigor-relevance dilemma cited in chapter 15 sums up this conundrum and seems to point to a key area of discussion and exploration for the following phases of the Action.

Section 6 – Visualization of outputs

The accessibility instruments described in section 3 of this report show a variety of visualization forms. Sometimes the output of accessibility tools can be numerical and listed in tables, matrix or datasheets, without offering any kind of visual outcome (e.g. tools in chapters 2, 13, 14, 17, and 20). But this kind of outcome can be needed for some users to make sense of accessibility which can otherwise be treated as a 'slippery' concept and not trusted by decision makers. Nevertheless, the most of accessibility tools generates a visual product, generally represented by bi-dimensional maps.

In order to analyse these different approaches to visualization, an overview will be shown, including only the instruments which generate a visual output. Furthermore, since many case studies have very similar output, their analysis will be conducted aggregating the tools on the basis of the technique of visualization. Main categories are:

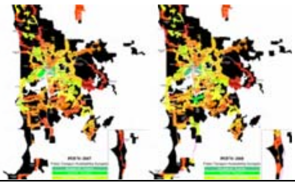
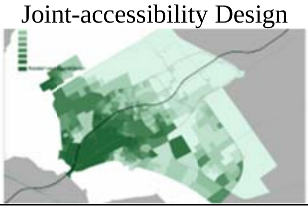
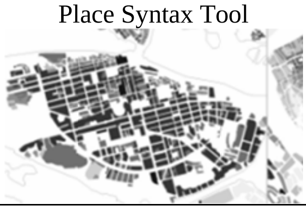
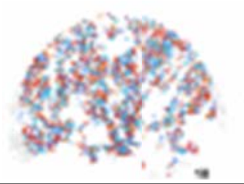
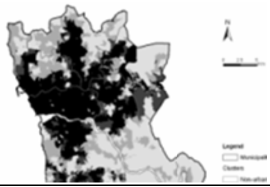
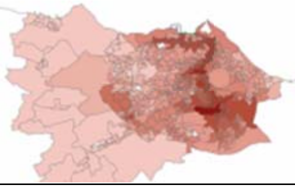
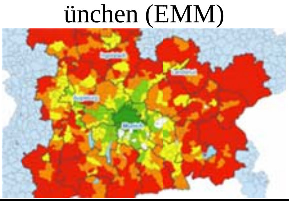
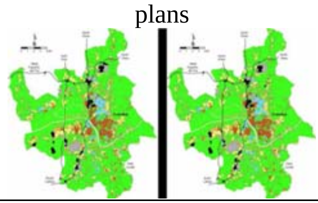
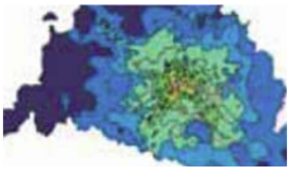
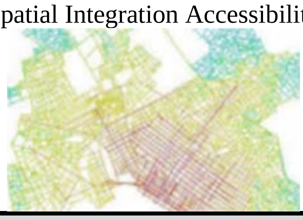
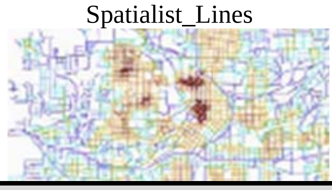
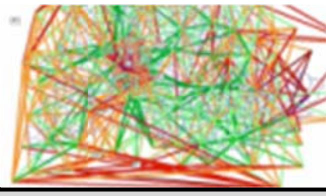
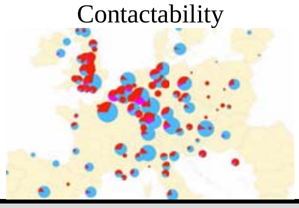
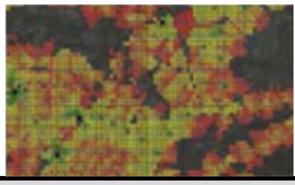
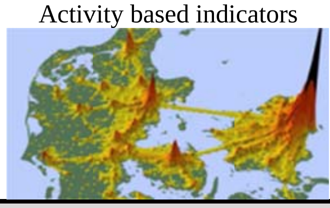
- 2D areal aggregation: data are grouped in macro-zones and classified on the basis of a colour scale;
- 2D axis-based maps: data are defined by the road network (e.g. Space Syntax based instruments) or by lines connecting points. The colour of shapes define the intensity of values;
- 2D point-based maps: data are represented by points on 2D maps. Size and colour of shapes define the intensity of values;
- 3D images: maps with a third, z-axis;
- no visual output: tools with no visual output described.

The accessibility instruments has been ordered as shown in the table on next page.

Only 5 of 22 tools do not report a visual output, highlighting the importance of visual communication for the most of the studies. Nevertheless, communication is mostly intended to provide knowledge rather than simply present data. In fact, except in one case (Activity based indicators of connections and access needs/chapter 4), all the accessibility instruments which have a visual output make use of bi-dimensional maps, preferring traditional methods of communication which are commonly used in spatial studies. This can be due to several factors. Firstly, 2D maps are generally perceived as more easy to understand for a wider range of people with different levels of expertise. Secondly, accessibility studies involve the use of spatial indicators which perfectly fit geo-referenced representations. Thirdly, input data are bi-dimensional. Finally, the different approaches to the study of accessibility do not cover the z-dimension, projecting all the connections to the ground level.

The half of tools represents data by the use of areal aggregation, generally based on the administrative boundaries of studied areas. This technique provides results highly dependent on the scale of aggregation, which is generally a balance between the dimension of the area and the amount of data to consider.

Table. **Tools aggregation according to their type of output visualization**

2D areal aggregation					
1	SNAMUTS 	**12**	Joint-accessibility Design 	**19**	Place Syntax Tool 
5	Himmeli 	**15**	SAL 	**21**	SNAPTA 
7	Erreichbarkeitsatlas der EuropäischenMetropolregionMünchen (EMM) 	**16**	Cellular automata modeling for accessibility appraisal in spatial plans 	**22**	ACCALC 
11	Gravity based accessibility measures 	**18**	Isochrone Metrosur 		
2D axis-based maps					
3	Spatial Integration Accessibility 	**9**	Measures of Street Connectivity Spatialist_Lines 	**8**	RIM 
2D point-based maps				**3D images**	
6	Contactability 	**10**	InViTo 	**4**	Activity based indicators 
No visual output					
2	Retail Cluster Accessibility				
13	Method for determining the max. size of shops				

14	GDATI
17	Land Development Potential
20	Social spatial analysis

Space syntax based tools (3/Spatial Integration Accessibility and 9/Measures of Street Connectivity: Spatialist_Lines) use the road network to visualize the value associated to their indicators. This allow to define the behaviour of each axis in relation to the whole area, creating a well performing visualization for describing the relations among the parts. Nevertheless, they seem more suitable in testing alternative project options rather than generate useful information for project design. Also the German Guidelines for Integrated Network Design/chapter 8 shows its output by the use of coloured axes, but the overlapping of axes creates a somewhat confused information.

Point-based maps are used by just two tools and in a similar way but at different scales. The Contactibility/chapter 6 uses elements of info-graphic to implement the readability of a very large scale map, generating a picture which highlights well the size and location of value clusters. On the other side InViTo/chapter 10 proposes a point output at urban scale where points vary in colour and size according to indicator values.

The overview on tool shows that the techniques of visualization are not affected by the scale of representation, but rather by the type of data aggregation. In determining the required visualization approach it seems necessary to first understand the intended audience and what the planner hoped they will do when they see the visualization. Among the accessibility tools presented in this report, the purposes of visualizations mostly focus on data explanation to high and medium experts, with map-based knowledge. All the visual outputs, both concerning policy support and scientific enquiry, provide representations which distil complex concepts into relatively simple maps and graphs helping planners to understand spatial dimensions of key accessibility statistics. Some visualizations use more artful techniques, which can be helpful in facilitating engagement, but still remain knowledge-focused.

Most of the tools need calculation times within the range of hours to days. Only one tool (InViTo/chapter 10), allows data exploration, generally considered as the highest form of data knowledge, by the use of interactive dynamic maps which work in real-time.

The majority of tools show its outcomes with colours that refer to three common techniques: the first is the traditional green-yellow-red scale, the second resorts to the different gradients of the same colour while the third uses the opposition between red and blue to highlight the contrasts. These traditional approaches to the use of colour shows once again the purpose of these tools to provide results that can be understood by the most of people and, in particular, to inform spatial planners on the capabilities of an area to access another one or to be accessed.